

**I claim:**

1. A water softening apparatus adapted to be placed in fluid communication with a water drain, a processing device, a water source that provides water containing undesired ions, and a water tap that dispenses water for consumption, said water softening apparatus operative to remove the undesired ions from water processed thereby, comprising:

(a) a resin vessel sized and adapted to receive a selected volume of a fluid, said resin vessel containing an ion-exchange resin that is capable of chemically shifting between an active state operative to exchange selected preferred ions therein for the undesired ions contained in the water when in contact therewith and an exhausted state operative to exchange the undesired ions therein for the selected preferred ions contained in a regenerant solution when in contact therewith;

(b) a regenerant reservoir adapted to receive the regenerant solution containing the selected preferred ions; and

(c) a manifold in fluid communication with said resin vessel and said regenerant reservoir, said manifold having a first inlet in fluid communication with the water source, a first outlet in fluid communication with the water tap, a second outlet in fluid communication with the water drain, and a third outlet in fluid communication with the processing device, said manifold including a plurality of fluid pathways communicating between said inlet, said outlets, said resin vessel and said regenerant reservoir, and a plurality of valves associated with said fluid pathways that are configurable into a plurality of valve states whereby in a first valve state fluid circulates through said first inlet, through said resin vessel and through said first outlet, whereby in a second valve state fluid circulates from said regenerant reservoir through said resin vessel and through said second outlet, whereby in a third valve state fluid circulates from said regenerant reservoir through said resin vessel and through said third outlet, and whereby in a fourth valve state fluid circulates through said first inlet, through said resin vessel and into said regenerant reservoir.

2. A water softening apparatus according to claim 1 wherein said valves are further configurable into a fifth valve state whereby fluid circulates through said first inlet, through said resin vessel and through said second outlet.

3. A water softening apparatus according to claim 1 including a pump in fluid communication with said regenerant reservoir and said manifold and operative to pump regenerant solution from said regenerant reservoir to said manifold.

4. A water softening apparatus according to claim 3 including a flow controller in fluid communication with said regenerant reservoir and said manifold and operative to control a flow rate of the regenerant solution from said regenerant reservoir.

5. A water softening apparatus according to claim 1 wherein said resin vessel includes a first combination inlet/outlet in fluid communication with said first inlet of said manifold and a second combination inlet/outlet in fluid communication with said first outlet of said manifold.

6. A water softening apparatus according to claim 5 wherein said resin vessel includes a resin vessel outlet in fluid communication with said second outlet of said manifold.

7. A water softening apparatus according to claim 5 wherein said first combination inlet/outlet is further in fluid communication with said third outlet of said manifold.

8. A water softening apparatus according to claim 5 wherein said second combination inlet/outlet is further in fluid communication with said regenerant reservoir.

9. A water softening apparatus according to claim 5 wherein said manifold includes a third combination inlet/outlet in fluid communication with said regenerant reservoir.

10. A water softening apparatus according to claim 1 wherein said manifold is a modified Autotrol Series 169 multi-port valve.

11. A water softening apparatus according to claim 1 wherein said ion-exchange resin is a shallow shell/shortened diffusion path resin.

12. A water softening apparatus according to claim 1 wherein said ion-exchange resin is selected from the group consisting of Purolite SST and Purolite C100FM resins.

13. A water softening system, comprising:

- (a) a water source that provides water containing undesired ions;
- (b) a water tap that dispenses water for consumption;
- (c) a water drain;
- (d) a processing device;
- (e) a regenerant reservoir that is sized and adapted to receive a selected volume of a regenerant solution containing selected preferred ions;
- (f) a resin vessel sized and adapted to receive a selected volume of a fluid;
- (g) an ion-exchange resin disposed in said resin vessel, said ion-exchange resin capable of chemically shifting between an active state operative to exchange the selected preferred ions therein for the undesired ions contained in the water when in contact therewith and an exhausted state operative to exchange the undesired ions therein for the selected preferred ions contained in the regenerant solution when in contact therewith; and
- (h) a manifold in fluid communication with said resin vessel and said regenerant reservoir, said manifold having a first inlet in fluid communication with said water source, a first outlet in fluid communication with said water tap, a second outlet in fluid communication with said water drain, and a third outlet in fluid communication with said processing device, said manifold including a plurality of fluid pathways communicating between said inlet, said outlets, said resin vessel and said regenerant reservoir, and a plurality of valves associated with said fluid pathways that are configurable into a plurality of valve states whereby in a first valve state water from said water source circulates through said first inlet, through said resin vessel and through said first outlet to said water tap when said ion-exchange resin is in

the active state thereby to remove the undesired ions from the water, whereby in a second valve state regenerant solution circulates from said regenerant reservoir into said resin vessel and water circulates from said resin vessel through said second outlet to said water drain, whereby in a third valve state regenerant solution circulates from said regenerant reservoir into said resin vessel when said ion-exchange resin is shifted toward the exhausted state thereby to shift the ion-exchange resin toward the active state and form a waste solution that circulates through said third outlet to said processing device, and whereby in a fourth valve state water from said water source circulates through said first inlet, through said resin vessel and into said regenerant reservoir thereby to replenish the volume of fluid therein.

14. A water softening system according to claim 13 wherein the undesired ions are calcium and magnesium ions.

15. A water softening system according to claim 13 wherein said processing device is an evaporation device.

16. A water softening system according to claim 13 wherein the regenerant solution is a brine solution.

17. A water softening system according to claim 13 wherein said valves are further configurable into a fifth valve state whereby water from said water source circulates through said first inlet, through said resin vessel and through said second outlet to said water drain.

18. A method for softening water that contains undesired ions, comprising:

(a) providing an ion-exchange resin capable of chemically shifting between an active state operative to exchange selected preferred ions therein for the undesired ions contained in the water when in contact therewith and an exhausted state operative to exchange the undesired ions therein for the selected preferred ions contained in a regenerant solution when in contact therewith;

(b) contacting said ion-exchange resin with the water that contains the undesired ions when said ion-exchange resin is shifted toward the active

state, thereby to remove the undesired ions from the water and shift said ion-exchange resin toward the exhausted state;

(c) contacting said ion-exchange resin with the regenerant solution containing the selected preferred ions when said ion-exchange resin is shifted toward the exhausted state, thereby to remove the preferred ions from the regenerant solution so as to shift said ion-exchange resin toward the active state and form a waste solution containing the undesired ions; and

(d) collecting said waste solution thereby to permit selective disposal of the undesired ions via a processing device that is separate from a drainage line.

19. A method according to claim 18 wherein the step of providing said ion-exchange resin includes providing said ion-exchange resin in a resin vessel sized and adapted to receive a selected volume of a fluid.

20. A method according to claim 19 wherein the step of contacting said ion-exchange resin with the regenerant solution includes first contacting said ion-exchange resin with the selected volume of the regenerant solution thereby to displace the selected volume of water from said resin vessel, and passing the selected volume of water to a water drain.

21. A method according to claim 19 wherein the step of contacting said ion-exchange resin with the regenerant solution includes contacting said ion-exchange resin with between 0.25 and 2.0 bed volumes of the regenerant solution.

22. A method according to claim 19 wherein the step of contacting said ion-exchange resin with the regenerant solution includes transporting the regenerant solution from a regenerant reservoir into said resin vessel.

23. A method according to claim 22 wherein the regenerant solution is transported by pumping the regenerant solution from the regenerant reservoir into said resin vessel.

24. A method according to claim 18 wherein the step of collecting said waste solution includes transporting said waste solution to an evaporation device.

25. A method according to claim 18 including the step of rinsing said ion-exchange resin with water thereby to form a rinse solution and thereafter transporting the rinse solution to a regenerant reservoir.

26. A method according to claim 25 including the step of adding rock salt to said regenerant reservoir, thereby to form a brine solution from said rinse solution.